NOTES ON THE MORPHOLOGY AND DEVELOPMENT OF TWO SPECIES OF EUDENDRIUM.[1]

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The observations presented here were made while describing and cataloguing hydroids collected at Bermuda during the summer of 1903. They have to do with two species of the genus *Eudendrium*. In one of these, *E. ramosum*, the development of the female gonophore is outlined, since no such account, so far as I am aware, has yet been given for any member of the genus. To a review of the histological conditions found in *E. hargitti* is added a description of its oögenesis which is unique for the genus in that the egg grows by the bodily absorption of entoderm cells. *Eudendrium hargitti* is here described for the first time.

To those who are acquainted with the contributions of Professor Charles W. Hargitt to our knowledge of the genus, the significance of the specific name will be evident. I wish to acknowledge my personal obligation to Professor Hargitt for suggestions and criticisms relating to my work.

Development of the Female Gonophore of Eudendrium ramosum.

The egg cells destined for the female gonophore here, as in all members of this genus, have their origin in the unfascicled branches of the mature colony and pass distally to the region where the future gonophore is to develop. They are first distinguished from epithelial cells by their deeply staining cytoplasm and large nuclei. They are found scattered along through the entoderm of the branches and pedicels and are most abundant close to hydranths bearing young gonophores. They also may be seen in the entoderm of hydranths which as yet show no external signs of gonophores.

Conditions point clearly to their migration up the branches. They show an increase in size proportional to their proximity to

[1] Contributions from the Zoölogical Laboratory of Syracuse University.

the end of the branch. Near the terminal hydranth they are so large as to crowd the neighboring entoderm cells, bulging the entoderm inward and mesoglœa outward. Their shape and position are such as most easily to force their way along the branch. They are flattened between mesoglœa and entoderm and their thin edges are inserted, wedge-like, between the two layers. In the fixed material I could find no indication of pseudopods. The entoderm cells about them are compressed and distorted in the way we would expect if the egg should move along under them.

There are two types of female gonophores differing so much in size and position that one might reasonably consider them entirely independent, were it not for the evidence of their common origin. In one type the outline of the spherical egg can be readily seen. An entodermal thickening passes half way round it extending from its attachment to hydranth, up over the top, to a point opposite its origin (Fig. 1). Here the ridge divides into a pair of branches which form open coils on opposite sides of the egg. Other gonophores have a distinctly different position in the colony. They are ovoid and the egg is largely hidden by a sheath of ectoderm and entoderm which on account of its development may be looked upon as a straight spadix (Fig. 2). The two kinds have been termed orthospadiceous and streptospadiceous according as the spadix is straight or coiled.

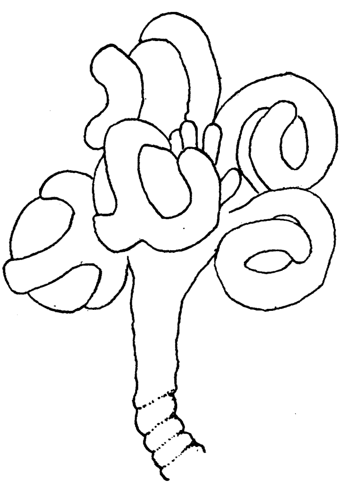

FIG. 1.

Streptospadiceous gonophores form whorls around the bodies of hydranths. Two, four, five or six gonophores are usually associated. Either the single terminal hydranth of a branchlet bears the gonophores or several succeeding hydranths may do so. The appearance of a gonophore terminates any further growth of a branchlet.

The earliest indication of the gonophore is an outwardly directed pocket of ectoderm and mesoglœa containing the egg

(Fig. 3). This is produced by the active proliferation of the ectoderm adjoining the egg. For a time the cells differ little from those of the hydranth ectoderm. Soon the entoderm just above the egg begins to form a blunt tube of columnar cells opening into the enteric cavity. The end grows outward between egg and mesoglœa. Growth of the base aids in carrying the egg out from the general surface of the hydranth (Fig. 4.) Continued elongation brings the end of the tube over the top of the egg and down the outside where it divides sending a branch inward and upward on either side to form the coil. Viewed from the side the spadix now looks like a spiral of one and a half turns. Linear growth of the spadix is nearly complete when the egg has one third of its mature diameter. It stands out from the surface at first, but in time becomes flattened against the egg.

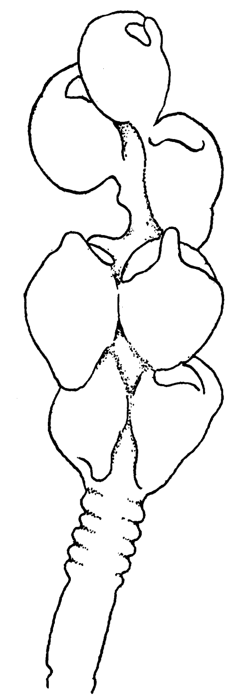
FIG. 2.

The ectoderm undergoes a gradual change to a thin tough sheath covered by a tenuous perisarc. It passes over the spadix and elsewhere is separated from the egg by the mesoglœa only. Together with the base of the spadix, it forms the stalk of the gonophore.

While the spadix is developing the egg rounds out into a sphere and rapidly enlarges. Its increase in bulk is due to the formation of large granules of deutoplasm. Weismann, '81[1], describes a contraction and expansion of the spadix in the living gonophore of *Coryne pusilla* which he thinks functions to move the nutritive fluid, used by the growing egg. Variations in the diameter of spadix lumen of *E. ramosum* suggest that the same motion occurs in it. There can be no doubt that the egg absorbs nourishment through the walls of the spadix, as has been pointed out by others. Dr. Hargitt has suggested that the flattening of the spadix is due to the absorption by the egg of the contents of its cells.

Orthospadiceous gonophores occur near the proximal parts of the colony. When associated with the other type they are below them on the branch. Only near the base of the colony do they occupy the tips of the branches. They are preceded by the streptospadiceous gonophores in time of development, yet in mature colonies exceed them in abundance. A dozen clusters may occur on one branch and such branches be so numerous at the base of the colony as to form a considerable mass of gonophores.

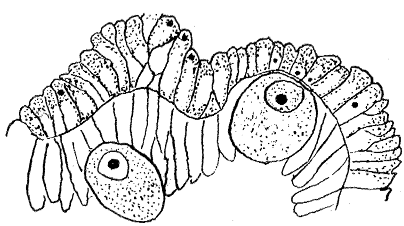

FIG. 3.

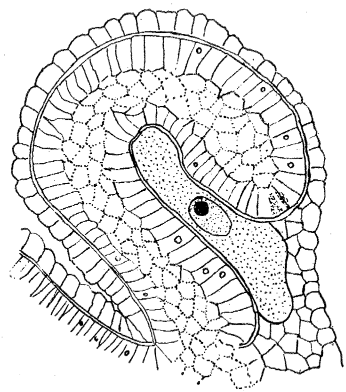

FIG. 4.

Five to seven gonophores usually form a cluster though any number from two to nine is not rare. They are attached along and around an annulated axis several times their length and of greater diameter than a hydranth pedicel. There is no definite form of arrangement. The base of one extends down part way below the top of another. They are generally associated as closely as their fusion on one side with the stem will permit. A division into a distal and proximal group at times is indicated by a slight free space on the axis.

In places where the two types are contiguous the transitional clusters may be present. As we would expect, they consist of orthospadiceous clusters below on a pedicel, with streptospadiceous, above on a hydranth. It is not an unusual thing to find gonophores that combine the two kinds of spadices.

The course of development in the orthospadiceous gonophore is much like that of the other type. The egg in the entoderm

of the hydranth lies, from the first, in contact with the mesoglœa. The ectoderm forms a pocket about it but does not separate it on its inner side from the body wall. While it is increasing in size, two entodermal processes pass out around it, the one from above and the other from below; of these the latter is the longest. They meet on the outside near the top. As they approach, a cup grows upward covering the surface between the lower process and the stem and sending ahead on either side a short projection. Growth ceases when two small spaces are left at the top, each of which is nearly cut in two by one of the lateral projections.

As the gonophore matures, the ectoderm secretes a perisarc which remains after the contents disappear. The ectoderm, itself, also becomes more opaque and tough. I find no peculiarity in the development of the egg. As one side is close to the enteric cavity there is no need of a spadix tube to supply nourishment. The entoderm of the gonophore is thrown into folds so disposed that the tissue is thin in the vicinity of the egg.

It seems probable that one type of gonophore arose from the other since intermediate gonophores are sometimes found. Conditions of occurrence and details of structure point to the streptospadiceous as the ancestral form. It is borne on the hydranth like the typical hydromedusan gonophore or medusa bud. The streptospadiceous gonophore is borne on a branchlet or pedicel. It grows on the younger part of the colony, is first to appear in the individual colony and so may well have been the first in the history of the species. The structure of gonophores and gonophore clusters point to the same conclusion. They show further that the process was one of simplification and involved a decrease in the time and material used in the developing gonophore. If we imagine the end of the coiled spadix to be directed upward and the whole structure to flatten down on the egg, thus fusing into a continuous cup whose rim is near the end of the spadix, we will have a spadix of the orthospadiceous type. Further simplifying of the gonophore by removing its pedicel and allowing it to sink into the stem for a third of its diameter will make it entirely orthospadiceous. Many of the large orthospadiceous clusters of six or eight gonophores are divided into a proximal and distal group by a small free space midway on the pedicel.

The comparison of a mixed cluster with these suggests strongly that the distal parts of their pedicels are homologous to hydranths and the proximal part to hydranth pedicels. A mixed cluster consists of a hydranth body bearing streptospadiceous gonophores and its pedicel bearing orthospadiceous gonophores. If its hydranth becomes reduced to a pedicel and its gonophores are simplified to the orthospadiceous condition we will have a structure corresponding exactly to the double orthospadiceous cluster described above both in form and number of parts. The division between the proximal and distal group has disappeared in half of the large clusters. It would be mere speculation to homologize the small clusters with the double ones. If the distal orthospadiceous gonophores of the clusters arose from the streptospadiceous type it seems further probable that the orthospadiceous gonophores on the pedicel arose from streptospadiceous pedicel-gonophores which in their turn are phylogenetically younger than those on the hydranth body.

General Morphology of Eudendrium hargitti.

The hydranths are of a bright reddish-brown, the stem of varying shades of brown. Stem unfascicled, colony twenty to fifty millimeters long, becoming nearly transparent near the extremities. Branches straight, few, nearly parallel to the main stem, distributed irregularly, joining the stem by an abrupt bend. Annulations at base of colony and branches, occasionally elsewhere. Hydranth most deeply colored at base of hypostome, tentacles from thirty-five to forty-five, in contraction forming two closely appressed rows, hypostome very mobile, contracting into a shallow cup or extending to a length greater than the hydranth body. Some hydranths provided with a groove near their base containing gland and thread cells.

Histology.

The majority of the histological details of this hydroid correspond with descriptions of other forms contributed by various authors. There are, notwithstanding, a sufficient number of unique conditions to make a general review not without value.

Hypostome.—One marked peculiarity of the hydranth is the unusual extent to which the hypostome may be expanded or contracted. As a result we have interesting conditions in the muscle processes and the thread cells. A glandular ring frequently found near the base of the hydranth is in part like a structure described by Weismann for two species of the genus *Eudendrium*, and not elsewhere recorded (Fig. 6).

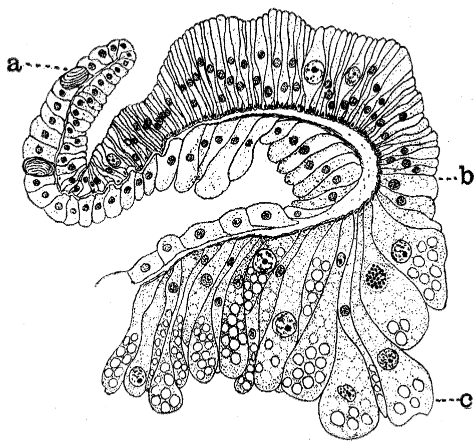

FIG. 5.

The ectoderm cells of the hypostome vary greatly in form during different phases of the contraction or expansion of the hypostome. They appear as pavement cells in the extended organ. If extremely contracted they are not only columnar, but the free ends bulge outward. Their cytoplasm is granular and often vacuolated. The nucleus, like that of entoderm, is large, with a nucleolus and at times a chromatin reticulum. Thread cells occur in a definite ring below the mouth (Fig. 5). Since the tentacles are largely destitute of them, it is apparent that the hypostome has usurped part of the protective function which belongs to the tentacles in most gymnoblastic hydroids. The entoderm of the hypostome is thicker than the ectoderm and consists of more diversified elements. The cells are cubical or columnar, depending upon the degree of extension of the hypostome. Greenish-yellow pigment granules occur here and there

through the tissue. Glandular activity is evinced in some cells by the deeply staining granular contents which may be seen discharging into the enteric cavity.

Gland cells of another type, most abundant near the mouth, present a striking appearance in the early stages of secretion. Small deeply staining granules form a single layer parallel to, or touching the cell wall near the free end. They are arranged with perfect regularity at equal distances and present a sieve-like effect. Certain hydranth cells which otherwise appear the same are full of the granules. I consider that the two types represent earlier and later stages of secretion. In any one hydranth the cells seem to go through the stage of secretion nearly at the same time. The nuclei are smaller than in any other cells of the hydranth.

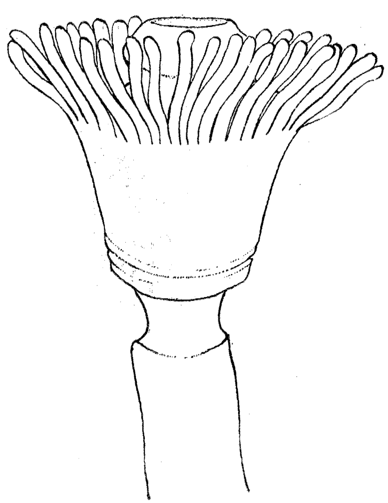

FIG. 6.

Body. — The entoderm of the body, as usual, contains many glandular digestive cells. They are very large about the internal opening of the hypostome and project downward so far as to form a thick ring which may nearly fill the cavity of a contracted hydranth. Some of them are granular and deeply staining. Others are vacuolated and often found in the act of discharging their contents into the enteric cavity. Since transitional cells are present it is probable that the first are earlier stages of secretion of a single kind of cell. May, '03, describes similar gland cells in *Corymorpha pendula.*

Spherical masses as large as nuclei appear in the gland cells and are given a saffron tint by Ehrlich's triple stain. Their interior is generally homogeneous but may contain a sphere suggestive of a nucleolus. No chromatin is found in them. They are frequently given off by gland cells and appear to be the remains of nuclei.

Pigment granules are present in all parts of the entoderm. They are most abundant in the gland ring. They are reddish-brown in living tissue and greenish-yellow and non-staining in alcoholic and formalin material. Lendenfeld, '83, found pigment in the entoderm of the hydranth of *Eucopella campanularia* and along the radial canals and about the egg of the medusa. Since it occurs in regions of greatest metabolism he concludes that it is the result of metabolism and therefore an excretory product. A similar point of view is taken by Hargitt, '04, in an extended consideration of the problem of coloring among Cœlenterata. In *E. hargitti* there is an association between the pigment and gland cells. It is most abundant in the gland ring where secretion is most active. It is found at the interior end of the cells like other secretory products. I found a few cells in the act of discharging it. Since it is as far as possible from the exterior, its position is plainly least suited for producing a coloring of the animal. Small amounts also occur in the pedicels and branchlets where the perisarc may preclude any color being seen from the exterior. Since the habits of the animal do not point to any advantage from its coloration I am inclined to think that the pigment has chiefly, if not entirely, its reason for existence in the metabolism of the animal. Between the gland cells the entoderm contains shorter, less deeply staining columnar cells. They become more abundant toward the base of the hydranth. Gland cells exceed the others on the folds of entoderm resulting from contraction of the hydranth.

Fibrous muscle processes from the bases of the ectoderm and entoderm cells, similar to those found by Kleinenberg in *Hydra*, occur here. They stain readily in iron hæmatoxylin and are so abundant as to offer an unusually good opportunity for study. They extend longitudinally along the mesoglœa in the ectoderm. In favorable sections single fibers may be traced the entire length of the hypostome. They are most abundant in the entoderm where they take a circular course. In a contracted hypostome they form a thick zone next the mesoglœa. Here it is easy to see that the fibrous process of the cell consists of a thin sheath of protoplasm surrounding a deeply staining filament. Longitudinal ectoderm and circular entoderm fibers occur to less numbers in all parts of the hydranth body and in the tentacles.

Tentacle. — The few thread cells of the tentacles occur for the most part in the thickened ectodermal tip. There are no external ridges as in *E. ramosum.* The entoderm cells appear polygonal in a cross section of the tentacle and form regular transverse layers of uniform thickness. The nuclei are so large as to appear to fill the interior of contracted tentacles. Longitudinal contractile fibers extend along the exterior of the thin mesoglœa. Their distal ends can sometimes be traced out among the ectoderm cells, though I could not demonstrate any connection with them.

Gland Ring. — Around the base of the hydranth the ectoderm is modified to form the gland ring mentioned previously (Fig. 6) The entoderm does not take any part in its structure. Weismann's description, '81[2], of similar rings refers to *E. racemosum* and *E. capillare.* He states that it consists of two ridges surrounding the base of the hydranth, separated by a narrow groove. The upper one has a varying number of thread cells; the lower is glandular and may be seen discharging its product which cements together a ring of débris about the base of the hydranth.

Above the upper ring occurs a muscular organ which Weismann terms a cnidophore. It is much like a large tentacle thickly beset with thread cells. The combined structure occurs only occasionally and more often on male than female colonies. He thinks the cnidophore a weapon developed as a protection against some especial enemy. The hydranth of *E. hargitti* very often possesses a double ring, but I have not found the cnidophore. The degree of development of the ring is extremely variable. At times it is plain to the unaided eye, again not readily detected even with sectioning and staining. Weismann does not describe gland cells in the upper ring. They are plentiful in the Bermuda form wherever it is devoid of thread cells. The distinctly glandular tissue is two or three cells thick and changes gradually into unmodified ectoderm. As noted by Weismann, the length of these cells is considerable, as they extend from the top of the ridges to the mesoglœa. Their cytoplasm is deeply staining and granular. The free end swells outward as in other gland cells. Often the upper ring presses down on the other so that the groove opens at a lower level than its interior. The bottom is formed from the extended bases of the gland cells.

The function of the upper ring of thread cells is probably protective, as we can hardly conceive of any offensive use in this place. The object of the glandular tissue of the two rings as well as of the groove seems obscure. The occurrence of rings without cnidophores goes to confirm Weismann's statement that cnidophores and rings have independent functions.

Pedicel and Stem. — There is little unusual in the histology of the pedicel and stem. The narrow neck connecting hydranth and pedicel consists of typical cambium tissue as described by Jickeli, '82; Seeliger, '94, and others. The enteric cavity is much constricted. The entoderm consists of brightly staining cells which appear in more vigorous condition than much of the tissue below them. The cell borders are well marked. Active gland cells occur here and there.

The ectoderm of the cœnosarc is first affected by degenerative changes of all the tissues of the colony. Large masses of thread cells occur in it, when thus affected, and they are in all stages of development. The youngest appear as small refractile bodies in cells full of deeply staining granular cytoplasm. As they grow larger a deeply staining rod appears in the axis of the body. It develops into a loop, and then into a coil of about ten loops. At this stage the membrane of the parent cell is filled by the structure and the shrunken nucleus is crowded between it and the membrane.

Weismann, '81[2], described slow peristaltic contractions of the cœnosarcal column of hydroids as well as amœboid movements of ectodermal processes along the inside of the perisarc. When a cover glass was pressed down over a freshly cut portion of a branch some processes were seen to withdraw from the perisarc and others to reach out to it. I find a condition of the cœnosarc very suggestive of such movements. In most branches the ectoderm is attached to the perisarc in but few places and is elsewhere contracted in varying degree. Doubtless a certain amount of contraction also results from the action of the killing fluid.

Bands of mesoglœa sometimes are found extending to the perisarc of pedicels and branches. The ectoderm reaches out and around the band to its point of attachment, thinning to a mere film which passes between it and the perisarc (Fig. 7).

The structure seems to have arisen through the mesoglœa in some way becoming attached to the perisarc without destroying the continuity of the cuticular border of the ectoderm cells. This could most easily take place during some time of expansion of the cœnosarc while the perisarc and mesoglœa were near each other. When contraction occurs for any reason, such as the killing of the tissue, the ectoderm would be drawn tensely up around the mesoglœal connective by the cuticular film.

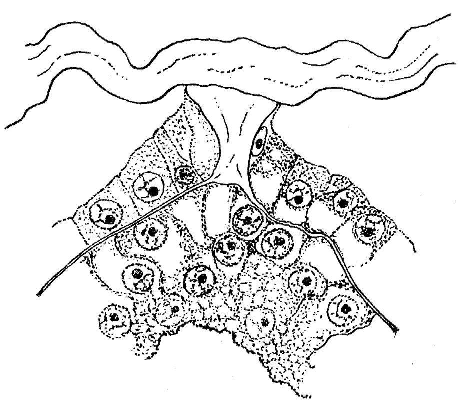

FIG. 7.

Weismann found a very similar or perhaps an identical condition in a species of *Eudendrium*. He says he found the cœnosarc near the band pulled out to form a pocket to the enteric cavity lined with glandular cells differing from the entoderm and forming a secretory organ. He does not describe a pulling out of the ectoderm to the point of attachment of band and perisarc.

I found a pocket in the enteric cavity resulting from the contraction of the cœnosarc. It seems to be a mechanical necessity that one be formed in the region held close to the perisarc by the band. When the cœnosarc is expanded there is no pocket. A few gland cells occur in the pocket but no more than elsewhere in the entoderm. It is plain that there is not a distinct glandular organ here and I doubt whether the structure is other than incidental. In the expansion and contraction of the cœnosarc it seems reasonable that the apparently viscid mesoglœa should become attached to the perisarc, especially in places where the entoderm has more or less deteriorated.

There is no peculiarity in the cœnosarcal ectoderm. It is columnar and has gland cells occurring singly or in groups similar in type to those of the hydranth body. As we pass into the larger branches it comes to consist of several layers as in other hydroids. The perisarc of young branches is generally homogenous. It shows lamination as it matures and often has dark interior layer.

Oögenesis.

Especial interest attaches to the development of the egg, because we have a condition hitherto undiscovered in any member of the genus. It is the absorption of the neighboring cells during a period of its growth. The manner in which this take place does not entirely correspond with that of any other species of hydroid whose oögenesis has been investigated. I confine this description to the streptospadiceous gonophore as very few young orthospadiceous gonophores were found. From examination of later stages of the latter, I am convinced that there is no marked difference in their method of development.

Origin and Migration. — The interest which has formerly centered in the question of the origin and migration of the eggs of Coelenterata and especially *Eudendrium* has resulted in a definite knowledge of the facts in many of the common species. Weismann, '71, and Hargitt, '04[1], have shown that the ova of *E. ramosum* originate in the ectoderm. Hargitt has since announced that in *E. tenue* there is a similar origin. In *E. racemosum* and *E. dispar* he found eggs in both layers, but the ectoderm was plainly the place of origin.

Because there has been controversy as to the parent tissue in *E. ramosum*, I examined several thousand sections from the branches and pedicels of *E. hargitti*, that any early migration of the egg from one layer to another should not escape me. Without an exception ova were found in the ectoderm. I was not able to find an ovum as small as an ectoderm cell because the ectoderm of the branches of mature colonies was in such poor condition. The smallest ova were about three times their bulk (Fig. 8). Since the eggs lie against the mesoglœa and push the adjoining cells to either side by their growth, it is beyond doubt that they have originated there. They occur singly.

Since the egg is found in the entoderm of the hydranth and is always in the ectoderm while in the pedicel, it is apparent that it must pass through the mesoglœa at the restricted neck which joins the hydranth and pedicel or in the lower part of the

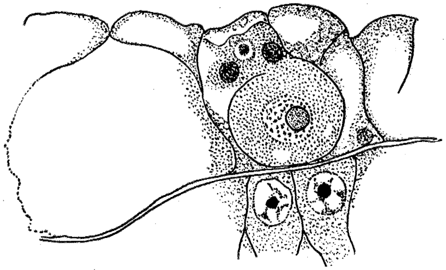

FIG. 8.

hydranth. It is probable that the passage is at the former place because not only is the wall very thin there but the egg on its arrival has often attained a diameter greater than the thickness of the wall. In a single preparation an egg was found in the ectoderm at the end of the pedicel. The mesoglœa at its anterior end was almost gone.

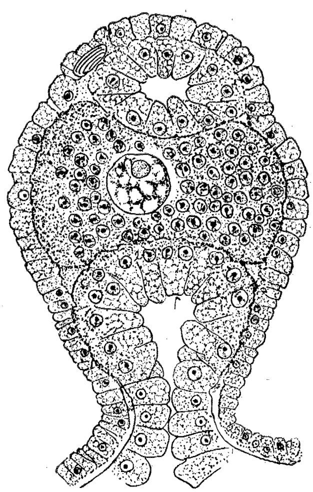

FIG. 9.

On its arrival in the hydranth the ovum is so large that it pushes the surrounding entoderm far out into the enteric cavity. The growth of the gonophore by the outpushing of the body layers, and the formation of the spadix duplicate the processes in *E. ramosum*. Since that has been already outlined it is not necessary to consider it here.

Growth of the Egg. — The smallest ova are dissimilar to the ectoderm cells in all details of structure. The cytoplasm is granular and deeply staining. It sometimes contains vacuoles which are most common near the periphery. The nucleus has a distinct membrane, a spherical nucleolus and a chromatin reticulum (Fig. 9).

During the stay of the ovum in the pedicel there is an occasional absorption of neighboring ectoderm cells. It is indicated by the presence of degenerating nuclei within the ovum. At first they differ little from the nucleus of an ectoderm cell. At a later stage the nuclear membrane disappears leaving a vacuole larger than the original nucleus and containing deeply staining chromatin rods surrounded by a non-staining watery substance. Similar nuclear degeneration may be traced more completely in the general ectoderm tissue up to the formation of the vacuole.

A more active cell absorption takes place when the egg reaches the hydranth (Fig. 10). As much as half of the egg membrane

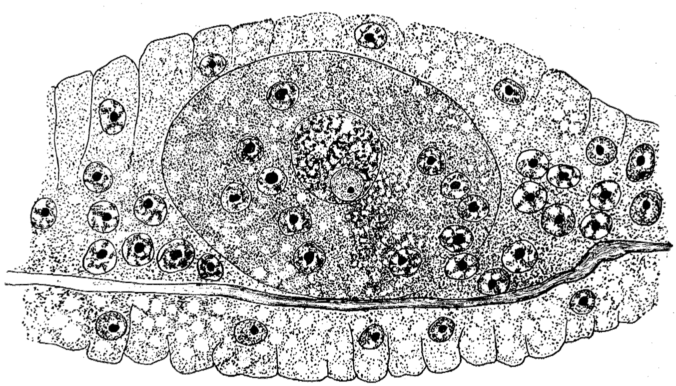

FIG. 10.

on one side may disappear in company with part of the walls of neighboring entoderm cells. A thin cuticular film stretching over the inner side of the egg separating it from the enteric cavity is all that remains of the walls of the nearest cells. The more distant cells retain the part of their wall farthest from the egg. There is no break in the continuity of the oöplasm and the fused cytoplasm of the entoderm cells. Nuclei are scattered about irregularly. Some occur definitely within the confines of the egg. As soon as the egg becomes enclosed in the gonophore it presents an unbroken periphery. When it has been carried away from the surface of the hydranth its nutriment comes by way of the spadix lumen which is a prolongation of the enteric cavity of the hydranth. Part of the columnar cells

constituting the spadix wall are in contact with the egg at one end since the spadix lies directly against the egg membrane. At their other end they extend for varying distances into the lumen producing a folded surface not unlike a digestive epithelium. It is probable that this large free surface is important in augmenting the absorption of food which is passed on to the egg (Fig. 11).

Two views have obtained as to the way in which the hydroid egg takes up the cells. Balfour's text-book of embryology, pub-

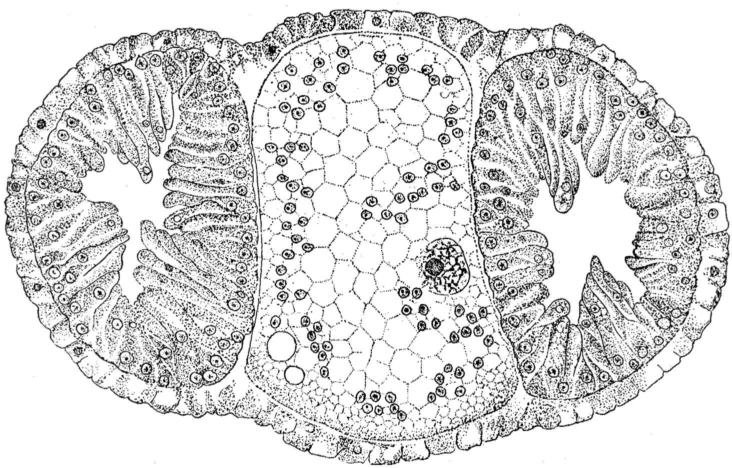

FIG. 11.

lished in 1879, states that they are amœboid and do so by putting up pseudopodia. Metchinkoff in 1887 described such a method in some medusæ. Tichomiroff in the same year found a condition in certain hydroid eggs which he terms an "amœboides Fressen." Smallwood, '99, saw indications of amœboid activities in the egg of *Pennaria tiarella*.

A different conception as to the process of absorption is found in Doflein's account, '96, of the development of the egg of *Tubularia larynx*. It is apparent from his discussion that he has studied the question carefully. He concludes that although eggs have processes like pseudopodia, there is no amœboid movement. Absorption occurs by the breaking down of the walls of the egg and adjacent cells to form a syncytium-like structure. When the

egg wall becomes defined again it includes the contents of other cells. Allen, '00, working on *Tubularia crocea* was led to Doflein's view, though the fact that the absorbed cell sometimes retains its outline in the egg is suggestive of amœboid activity.

The egg of *E. hargitti* is largely passive in the process of cell absorption. A syncytium-like structure is formed by the disappearance of the egg membrane in a limited region, and of the walls of adjoining entoderm cells. The border of the egg is, later, again defined, not by its activity so much as by the growth of the spadix which removes the egg from its former position. It is not surprising that the behavior of the egg finds an approximate parallel in *T. larynx* and *T. crocea*, when we consider that these species belong to a closely associated genus.

There has been a diversity of view as to the fate of the nuclei of cells absorbed by hydroid eggs as well as to the method of absorption. Ciamician, '79, applied the term "pseudozellen" to spherical bodies found in the egg of *T. mesembryanthemum* which he considered to be formed after the nuclei of the absorbed cells had disappeared. Brauer, '91, published the results of the study of the same species, in which he agreed with the conclusion of Ciamician as to the origin of the pseudo-cells. Also, in a contribution to the development of *Hydra*, he says that pseudo-cells are formed in the cytoplasm and are not degenerating nuclei.

The three papers already mentioned, by Doflein, Smallwood and Allen, described the nuclei of absorbed cells as undergoing divisions and degenerative changes characteristic of pseudo-cells. That name is therefore applied to them.

In this species, the history of the nuclei does not exactly correspond to any that have been outlined above but finds its closest parallel in the persisting of nuclei as pseudo-cells. I have not as much evidence as I would like regarding the absorption of nuclei by the egg near the place of its origin. This is due to the difficulty encountered in finding very young eggs. A considerable part of those I did find had nuclei of ectoderm cells, thus rendering it probable that there is an early stage of the egg when growth is expedited by the absorption of a few cells. For two reasons, I am convinced that the nuclei are absorbed before the egg leaves the pedicel; first, no extra nuclei were found in many

large eggs examined from the pedicel; second, as already stated, a nucleus was found in process of absorption in a small egg. As has been shown the period of most active absorption is during the stay in the wall of the hydranth. When the egg is first enclosed by the gonophore, nuclei are scattered thickly throughout the cytoplasm. As the deutoplasm is formed they are in part crowded toward the periphery. We might expect from the conditions in *Pennaria* and *Tubularia* to find the nuclei now passing through the characteristic changes of pseudo-cells, but nothing of the kind occurs. In eggs well on toward maturation, I detected no change in the nuclei. It would be of great interest to find whether the pseudo-cells are finally formed or whether the history of the nuclei is different from any yet described, in that they are gradually absorbed. The persistence of the nuclei during the maturation of the egg appears less strange when we consider that the ova grow very rapidly and that the period under consideration is but a comparatively few hours.

The results of the latest investigations of pseudo-cells seem to show that Brauer and Ciamician were wrong in the conception of their origin. If that be true, then the term rightly applies not only to the bodies found in the eggs of *T. larynx*, *T. crocea* and *P. tiarella*, but in *E. hargitti* as well, although we do not know whether the latter ever undergo like degenerative changes.

From the time of origin of the egg in the ectoderm until its enclosure in the gonophore the nuclear structure does not change though the size increases. As the gonophore approaches its mature proportions, the nucleus becomes excentric and may lose its membrane. I did not follow the phenomena of maturation farther.

Yolk granules appear in the egg while the gonophore is small. They are usually first developed around the central nucleus. In any case the periphery is the last to become filled with them. They enlarge and increase in number so as to take a polyhedral shape to mutual pressure. They are separated by a thin film of protoplasm. As in *E. ramosum*, the spadix becomes flattened upon the egg probably contributing its substance for nutrition.

Nourishment. — In connection with the study of the gonosome I found it of interest to compare the distribution of nourishment

in the young and sexually mature colonies as shown by their histological condition. In the former there is enough food not only for the hydranth and the rapidly growing cambium tissue at the ends of the pedicels, but for the small requirements of the cœnosarcal column down to the very base of the colony. In the latter, the rapid growth of the eggs must cause the absorption of a greater proportion by the hydranths and the pedicels of orthospadiceous gonophores. The tissue farthest removed from the food supply is the ectoderm of the cœnosarc. It is also least necessary to the economy of the colony at this period of its life. Accordingly we find it undergoing retrogressive change in mature colonies at the same time when gonophores are vigorously developing. The last part of the cœnosarc to cease its activity is the cambium tissue, close to the hydranths.

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